



DESCRIPTION

<TITLE OF THE INVENTION>

Head Support Device and Disk Drive Using Same

FIELD OF THE INVENTION

[0001] The present invention relates to a head support device using a head slider provided with a floating type head for performing recording and reproducing operation on a disk-like recording medium such as a magnetic disk and optical magnetic disk, and a disk drive for performing recording and reproducing operation by using the head support device.

BACKGROUND OF THE INVENTION

[0002] Recently, there is has been a remarkable advance in technology of a disk drive (hereinafter also called a disk recording and reproducing unit) for performing recording and reproducing operation on a disk-like recording medium (hereinafter also called a recording medium) such as a hard disk and optical disk, and the use is expanding in various fields in addition to its conventional use for computers. Such a disk drive is further required to be capable of higher density recording, stable recording and reproducing without damage to the recording medium or the head slider even in case of receiving disturbance such as shocks, and is also required to be reduced in size so that it can be mounted on portable equipment.

[0003] As an example of a head support device of a disk drive having a conventional floating type head, a conventional head support device in a magnetic recording and reproducing unit such as a hard disk drive will be described by using the drawings.

[0004] Fig. 17 is a plan view showing ~~the~~ a configuration of a head support device of a conventional magnetic recording and reproducing unit, and ~~the~~ also showing a relationship between the head support device and magnetic recording medium (hereinafter also called disk).

[0005] In Fig. 17, head support arm 108 of head support device 100 comprises support arm 102 ~~being which~~ is relatively low in rigidity, plate spring 103, and support arm 104 ~~being which~~ is relatively high in rigidity, and head slider 101 provided with a magnetic head (not shown) is disposed on ~~the an~~ underside of one end portion of the support arm 102.

[0006] Also, magnetic recording medium 107 is arranged so as to be rotated by spindle motor 109, and when the magnetic recording and reproducing unit is operated, the magnetic head mounted on the head slider 101 obtains a given amount of floatation due to ~~the relation~~ a relationship between the buoyancy created by the air flow produced by the rotation of the magnetic recording medium 107 and the activation of the head support device 100 which activates the head slider 101 toward the magnetic recording medium 107.

[0007] The head support device 100, during recording and reproducing ~~operation~~ operations, is rotated about bearing portion 105 ~~by the~~ via action of voice coil 106 disposed on the support arm 104, and thereby, the magnetic head mounted on the head slider 101 is positioned against the a desired track of the magnetic recording and reproducing medium 107 in order to execute the recording and reproducing operation.

[0008] Next, the configuration and action of a conventional head support device will be described in detail with reference to Fig. 18.

[0009] Fig. 18 is a perspective view of an essential portion of the head support arm 108 comprising the support arm 102, and the head slider 101, in a conventional head support device. The head slider 101 is fixed on tongue-like portion 113 disposed at the an end of flexure 115. Also, the other another end of the flexure 115 is fixed on the support arm 102. For example, a ginbai spring is used as the flexure 115, which is configured so as to be able to pitch and roll against the head slider 101. The head slider 101 is fixed onto the flexure 115, for example, by using adhesive, while the flexure 115 is fixed onto the support arm 102, for example, by welding. The An end portion of support arm 102 is provided with dimple 114 which serves to apply a load to the head slider 101, and a predetermined load is applied to the head slider 101 via the dimple

114. The configuration of the head support arm 108 includes the support arm 102 having the dimple 114, the flexure 115 having the tongue-like portion 113, and the head slider 101.

[0010] By using such head support arm 108, when a recording and reproducing operation is executed on the a magnetic recording and reproducing medium 107 (not shown in Fig. 18) while being rotated, the head slider 101 is subjected to three forces such as a load applied via the dimple 114, a positive force that acts to cause the head slider to rise ~~float~~ up from the magnetic recording medium due to ~~the~~ air flow, and a negative force that acts to cause the head slider to approach the magnetic recording medium, and then, the head slider 101 is floated due to ~~the~~ balance of these forces, and in a state of ~~keeping the~~ maintaining an amount of floatation, ~~it the~~ head slider executes the recording and reproducing operation ~~by via~~ an information conversion element (not shown) while driving a rocking ~~means device~~ for positioning the head slider to a predetermined track position.

[0011] However, in the conventional disk drive, when external shocks are ~~given applied~~ to the unit, the head slider bumps against or comes into contact with ~~the a~~ recording medium, causing the head slider and the recording medium to be worn or damaged, which may sometimes result in breakdown of ~~the data or damage to the device~~ disk drive. Accordingly, a method for preventing external vibration from being transmitted to ~~the a~~ main body of the ~~device~~ disk drive is proposed (for example, refer to Japanese Laid-open Patent H9-153277) in that there is provided a fitting member for receiving external vibration, and ~~the a~~ main body of the disk drive is bonded to the fitting member by using a flexible heat insulating member ~~of flexible structure~~. Thus, a disk drive which is strong against external vibration can be realized, but the ~~whole device~~ disk drive in its entirety is relatively large in size, and it is difficult to mount such a ~~device~~ disk drive in portable equipment required to be small-sized and light-weight.

[0012] Accordingly, it is necessary to improve ~~the~~ shock resistance of ~~the a~~ head slider and support arm, or head support arm itself, and at the same time to achieve ~~the purposes~~ objectives such as miniaturization of ~~the a~~ disk drive and improvement of its shock resistance. Particularly,

since the head slider is opposed to ~~the~~ a recording medium while ~~keeping~~ maintaining a delicate amount of floatation against the recording medium, it is required to prevent the head slider and the recording medium from being seriously damaged when shocks are ~~given~~ applied thereto. However, ~~the~~ a shape of ~~the~~ a surface of the head slider opposing to ~~the~~ a recording medium of ~~the~~ a head slider is not usually devised for ~~the~~ a purpose of improving the shock resistance, but in many cases, improvements are made in various ways in order to stabilize ~~the~~ an amount of floatation at ~~the~~ an air outflow side of the head slider where ~~the~~ an information conversion element is disposed, as against the variations of skew angle and atmospheric pressure.

[0013] For example, there is a proposal of a head slider configuration such that a positive pressure generating section for generating great positive pressures, and a negative pressure generating section for generating negative pressures, are concentrated at ~~the~~ an air outflow side of the head slider in order to increase the rigidity of an air layer at the air outflow side (for example, refer to Japanese Laid-open Patent H-10-283622). In such a configuration, when the head slider pitches and changes in its floating posture, there exists a point as a focal point at which ~~the~~ an amount of floatation does not vary, and ~~the~~ a position of this focal point can be near ~~the~~ an air outflow end of the head slider where ~~the~~ an information conversion element is disposed. In this way, it is possible to execute stable recording or reproducing of information almost without change in ~~the~~ an amount of floatation of the head slider near the information conversion element due to the action of positive and negative pressures even in case of variations of the skew angle, the atmospheric pressure, the external forces due to rocking, or the load.

[0014] Also, as a head slider structure for reliably realizing a low-level amount of floatation, there is a proposai of a head slider configured in that there exists a position as an immovable point at which ~~the~~ an amount of floatation does not vary, and the immovable point is positioned at ~~the~~ an air outflow end side of the head slider (for example, refer to Japanese Laid-open Patent H8-227514). That is, in a head slider wherein, when a push load is applied in ~~the~~ a direction of ~~the~~ a recording medium, ~~it causes the generation of a positive pressure~~ is generated that acts to

float the head slider with ~~the~~ viscous flow of air generated by ~~the~~ rotation of the recording medium, and a negative pressure is generated by ~~the~~ air flowing into ~~the~~ a groove formed in ~~the~~ a head slider surface, the head slider is structurally constructed such that ~~the~~ a center of negative pressure generation is positioned a little closer to ~~the~~ an air inflow side of the head slider than to ~~the~~ an action point of the push load.

5 [0015] Due to this structure, when an external force (moment) acts on the head slider to move it ~~upward~~ upwardly, a negative force acts to cope with the external force so that the head slider can be ~~kept~~ maintained in a stable state. That is, it is disclosed that even when an external force acts to move the head slider ~~upward~~ upwardly, a negative force will act against the external force, and since the air outflow end side of the head slider fitted with ~~the~~ an information conversion element is substantially ~~the~~ a rotational center of balance or ~~the~~ an immovable point, 10 ~~the~~ a distance from the information conversion element to ~~the~~ a recording medium surface remains almost unchanged.

[0016] As described above, in a head support device of a magnetic recording and reproducing unit, it has been necessary to apply a predetermined load to the head slider in ~~the~~ a direction of ~~the~~ a magnetic recording medium ~~to the head slider~~ in order to prevent off-tracking 15 of ~~the~~ a magnetic head, mounted on the head slider, by ~~keeping~~ maintaining the head slider in a stable state of floating even in case of external shock or vertical movement of the magnetic recording medium during ~~the~~ a recording and reproducing operation. Also, ~~in the~~ during a recording and reproducing operation of ~~the~~ a magnetic recording medium, it has been necessary 20 for ~~the~~ a head support device to have appropriate flexibility so that ~~the~~ a head slider may follow ~~the~~ vertical movement or the like of the magnetic recording medium. Further, in order to reduce the size of ~~the~~ a magnetic recording and reproducing unit, to reduce ~~the~~ thickness in particular, it has been necessary to thin ~~the~~ a head support device in a direction vertical to ~~the~~ a magnetic recording medium surface.

25 [0017] However, in a conventional head support device, as described above, since it is

configured in that a support arm is connected by a plate spring to a coupling portion, it is required to satisfy ~~the~~ incompatible requirements in order to satisfy various requirements ~~for~~ of the head support device. That is, specifically, firstly to obtain a stable floating status of ~~the~~ a head slider with ~~the~~ a magnetic head mounted thereon, it has been necessary for the plate spring to have a reaction force that is ~~enough~~ sufficient to apply a necessary load to the head slider.

5 [0018] Also, it has been necessary for the head support device to have appropriate flexibility in order to prevent ~~the~~ a load applied by the head slider to ~~the~~ a magnetic recording medium from being varied due to ~~the~~ a vertical movement of the magnetic recording medium, or ~~the~~ manufacturing variations or the like of ~~the~~ a distance between the head slider and the magnetic recording medium of every magnetic recording and reproducing unit in mass-production. In the
10 conventional head support device, it has been designed ~~in~~ that there is provided a notch in plate spring 103 as shown in Fig. 17, which serves to lower ~~the~~ rigidity of the plate spring 103 and to lessen ~~the~~ a spring constant for ~~the~~ a purpose of providing ~~it~~ the plate spring with flexibility.

[0019] Also, in case the support arm is structurally thinned in order to lower ~~the~~ rigidity of the plate spring, ~~the~~ frequency at a main resonance point, that is so-called resonant frequency, is
15 low and causes a vibration mode such as twisting when the head support device is moved for positioning, and consequently, it takes much time for settling ~~the~~ a vibration mode ~~then~~ generated, resulting in ~~arising~~ a ~~limitation in~~ shortening ~~the~~ of access time.

[0020] Further, in the conventional head support device, since ~~the~~ a center of gravity is positioned a little closer to the magnetic head than to the plate spring, when strong shock or the
20 like is given exteriorly applied to the magnetic recording and reproducing unit ~~from the outside~~, ~~the~~ buoyancy due to ~~the~~ air flow generated due to ~~the~~ rotation of ~~the~~ a magnetic recording medium is unbalanced against ~~the~~ an activating force of the head support device which activates the head slider toward the magnetic recording medium ~~side~~, and then a phenomenon takes place such that the head slider jumps from the magnetic recording medium. As a result, the head slider
25 bumps against the magnetic recording medium and ~~it~~ may cause magnetic damage or mechanical

damage to the magnetic recording medium.

[0021] Also, in the above example of a head slider, to prevent ~~the~~ an amount of floatation at ~~the~~ an air outflow end of the head slider where ~~the~~ an information conversion element is disposed, a surface of the head slider opposing ~~to~~ a magnetic recording medium is provided and a load action point is arranged so that ~~the~~ an immovable point or focal point is positioned at the air outflow end of the head slider. Accordingly, even when ~~the~~ a floating posture is changed due to variation of ~~the~~ a skew angle, ~~the~~ atmospheric pressure, or ~~the~~ load, ~~the~~ an amount of floatation can be stabilized at ~~the~~ an air outflow end side where the information conversion element is disposed. However, comparing such variation with ~~a~~ an exteriorly applied shock ~~applied from outside~~, the shock is far greater than the variation, and therefore, it cannot be said that the proposal described above is effective to cope with shocks.

[0022] That is, when a great shock is applied to the head slider of which the immovable point or the focal point is positioned at the air outflow end, there may arise a situation such that the head slider is of negative pitch angle; that is, ~~the~~ an amount of floatation at the air inflow end side of the head slider is less than ~~the~~ an amount of floatation at the air outflow end side of the head slider. In ~~that~~ this case, it is unable to form an air layer between the surface of the head slider opposing ~~to~~ a magnetic recording medium and ~~the~~ a surface of the magnetic recording medium, ~~then~~ and thus the head slider does not float at all and is damaged due to bumping against the recording medium.

[0023] Also, in the proposal, the point at which ~~the~~ an amount of floatation remains unchanged even in case of variation in skew angle or the like is defined as the focal point, and the surface of the head slider opposing ~~to~~ the magnetic recording medium is shaped so that the position corresponds to the air outflow end of the head slider. Thus, nothing is mentioned about whether or not the immovable point corresponds to the focal point when external shocks are applied to the head slider.

[0024] Further, regarding ~~the~~ a proposal of a configuration such that ~~the~~ a position at which

the an amount of floatation remains unchanged is an immovable point, and the immovable point is positioned at the an air outflow end side of the head slider, the an amount of floatation at the air outflow end side of the head slider can be controlled in the a case of such a rotational moment as to move the head slider ~~upward~~ upwardly, but in a direction ~~vertical~~ perpendicular to the a recording medium surface, especially in the a case of a downward shock applied to the recording medium surface, where the head slider may bump against the recording medium surface even due to a slight shock.

[0025] Moreover, in a disk drive mounted in portable equipment, it is necessary to reduce the a diametric size of the a recording medium and also to lower the a recording medium rotating speed, and the speed of air flow on the a surface of a head slider opposing to the magnetic recording medium ~~of the head slider~~ becomes lower as compared with the prior art. In case the recording medium rotating speed is at ~~such~~ a low level, when a negative pitch angle is generated at the head slider due to shock, it is ~~unable to form an air layer~~ cannot be formed, and the a possibility of bumping against the recording medium is very much increased, but nothing is disclosed about this matter in the above ~~example of disclosure~~ examples.

[0026] The above problems are not peculiar to the a magnetic recording and reproducing unit, and there have arisen similar problems in a disk drive having a floating type head such as an optical disk drive and optical magnetic disk drive.

SUMMARY OF THE INVENTION

[0027] The present invention is intended to solve these problems, and the an object of the invention is to provide a head support device comprising a head slider whose shock resistance is improved because the head slider rotates in the a direction of pitch when an external shock is applied to the head slider, which ensures high flexibility while applying an adequate load to the a head on the head slider, which is thin and assures excellent shock resistance, ~~and~~. Another object of the invention is to provide a disk drive using the device such a head support device.

[0028] In order to solve the problems, the head support device of the present invention comprises a head, a support arm, with ~~the~~ a head disposed at one end thereof and of the support arm, an elastic member formed near ~~the other~~ another end of the support arm, and a first base arm having a coupling portion projected at one end of the first base arm, wherein ~~the~~ an end of the elastic member is fixed on to the first base arm, and the support arm or the first base arm is provided with a vertical rotation supporting point. Also, ~~it comprises~~ the head support device can comprise a head, a support arm with the head disposed at one end thereof and an elastic member formed near ~~the other~~ another end thereof, and a first base arm having a coupling portion projected at ~~the other~~ another end, wherein ~~the~~ an end of the elastic member is fixed on the first base arm, and the support arm or the first base arm is provided with a vertical rotation supporting point, and the head is disposed apart from the vertical rotation supporting point in ~~the~~ a longitudinal direction of the support arm, opposing to ~~the~~ a recording medium of the head slider. Also, ~~it is~~ the head support device can be configured in that near ~~the other~~ another end of the support arm at ~~the~~ an opposite side of the head, ~~an~~ the elastic member is formed in one-piece with the support arm along ~~the~~ a longitudinal center line of the support arm. Also, ~~it is~~ the head support device can be configured in that the head is mounted on a head slider, and the head slider is fitted on one end of the support arm via flexure. Also, ~~the head support device can be~~ it is configured in that a balancer is fitted on ~~the other~~ another end of said ~~the~~ support arm across said the vertical rotation supporting point from said ~~the~~ head slider. Also, the head support device of the present invention ~~is~~ can be configured in that ~~the~~ a surface of the head slider opposing to a recording medium is such that, when an external shock is applied to the head slider, suppose the a distance from ~~the~~ an action point of load that activates the head slider in ~~the~~ a direction of the recording medium to ~~the~~ an immovable point when the head slider rotates in ~~the~~ a direction of pitch is L_o ; ~~the~~ a length in ~~the~~ an air flow direction from ~~the~~ an air inflow end of the head slider to the air outflow end thereof is L_s ; then $0.5 < L_o < L_s < 2$, and when an external shock is applied to the head slider, suppose the distance from the action point of load that activates the head slider

toward the recording medium to the immovable point when the head slider rotates in the direction of pitch is L_o ; the length in the direction of air flow from the air inflow end of the head slider to the air outflow end thereof is L_s ; ~~the a~~ pitch angle of the head slider being afloat over ~~the a~~ recording medium surface is θ_p ; and ~~the an~~ amount of floatation from the recording medium surface at the air outflow end of the head slider is X_t , then $1 \leq L_o / L_d \leq 2.5$, where $L_d = (L_s / 2) + (X_t / \tan(\theta_p))$. Also, the head support device of the present invention ~~is~~ can be configured in that the elastic member is symmetrical about ~~the a~~ center line in the longitudinal direction of the support arm and peripherally provided with a U-shaped, V-shaped or \sqsupset -shaped through-hole. Also, the head support device of the present invention ~~is~~ can be configured in that the vertical rotation supporting point disposed on the support arm or the first base arm has two pivots. Also, the support device of the present invention ~~is~~ can be configured in that ~~the an~~ overall center of gravity as ~~the a~~ total center of gravity of the head slider, flexure, support arm and balancer is positioned on a plane vertical to ~~the a~~ recording medium including ~~the a~~ line that connects the respective peaks of the two pivots, thereby setting the mass of the balancer, ~~the a~~ center of gravity position, and ~~the a~~ fitting position. Also, the head support device of the present invention ~~is~~ can be configured in that the two pivots are disposed symmetrically about the center line in the longitudinal direction of the support arm. Also, the head support device of the present invention ~~is~~ can be configured in that a side reinforcement is disposed on ~~the a~~ side surface of the head slider in the a longitudinal direction of the support arm or a side reinforcement is formed by bending. Also, the head support device of the present invention ~~is~~ can be configured in that there is provided ~~the a~~ second base arm having a hole for connection to ~~the a~~ coupling portion of the first base arm at one end thereof of the second base arm, a bearing portion, and a driving means device on the other another end thereof of the second base arm. Also, the head support device of the present invention ~~is~~ can be configured in that the immovable point is obtained from ~~the a~~ ratio of ~~the~~ rotational rigidity of ~~the an~~ air layer generated between the surface of the head slider opposing to ~~a~~ recording medium ~~of the head slider~~ and the recording medium to ~~the~~ rotational

rigidity as against ~~the vertical~~ perpendicular displacement. Also, the head support device of the present invention ~~is~~ can be configured in that ~~the~~ a positive pressure generator disposed on the surface of the head slider opposing ~~to the~~ recording medium comprises a first positive pressure generator formed at a predetermined position so as to be perpendicular to ~~the~~ direction of air flow from ~~the~~ an air inflow end of the head slider, and a second positive pressure generator formed at a predetermined position from ~~the~~ an air outflow end at ~~the~~ a widthwise center vertical to ~~the~~ air flow direction of the head slider, and that the negative pressure generator is formed between the first positive pressure generator and the second positive pressure generator, and ~~the~~ a negative pressure center is positioned ~~near~~ nearer to the air outflow end side than to ~~the~~ an action point of load that activates the head slider toward the recording medium. Also, the head support device of the present invention ~~is~~ can be configured in that side rails are disposed on either side in ~~the~~ a widthwise direction of the head slider for ~~the~~ a purpose of connection to the first positive pressure generator. Also, the head support device of the present invention ~~is~~ can be configured in that the negative pressure generator is disposed in a nearly surrounded region at ~~the~~ a middle stage that is lower than ~~the~~ a surface of the positive pressure generator and higher than ~~the~~ a surface of the negative pressure generator with reference to the surface of the positive pressure generator. Also, the head support device of the present invention ~~is~~ can be configured in that the action point of load that activates the head slider toward the recording medium is ~~the~~ a center of gravity of the head slider. Also, the head support device of the present invention ~~comprises~~ can comprise a head support arm provided with a head slider holding member which holds the head slider, and a support arm which fixes ~~the other~~ another end of the head slider holding member. Further, the head support device of the present invention ~~is~~ can be configured in that ~~the~~ suction toward ~~the~~ a recording medium generated on ~~the~~ an air lubricated surface of the head slider is greater than ~~the~~ an equivalent mass of the head support device.

[0029] By using these configurations, it is possible to provide a head support device which is excellent in flexibility and shock resistance and capable of high-speed access while applying an

adequate load to the head, and also, the support arm supported on ~~the a~~ pivot as a vertical supporting point is able to freely rotate in a direction ~~vertical-perpendicular to the a~~ recording surface of the recording medium, thereby realizing a head support device that may execute novel operation unlike the prior art.

[0030] Further, by using these configurations, no rotational force against external shock is generated around the line (rotational axis) that connects the respective peaks of the two pivots disposed on one of the first base arm and the support arm, and therefore, the head slider can be prevented from bumping against ~~the a~~ recording medium surface and causing damage to the ~~head~~ or recording medium or head mounted on the head slider. Accordingly, it is possible to realize a head support device which is stable and free from excessive vibrations.

[0031] Also, in order to solve the above problems, the disk drive of the present invention comprises a recording medium with a recording medium layer formed on ~~the a~~ surface thereof, a rotating ~~means-device~~ for rotating the recording medium, and a head support device provided with a head slider with a head mounted on one end and a driving ~~means-device~~ mounted on ~~the other another~~ end thereof, ~~wherein the~~. The head support device includes a support arm with a head disposed on one end thereof and an elastic member integrally formed along ~~the a~~ longitudinal center line near ~~the other another~~ end thereof, a balancer fitted on ~~the other another~~ end of the support arm, and a first base arm having a projected coupling portion on one end thereof, and ~~the an~~ end portion of the elastic member is fixed on the first base arm, and the support arm or the first base arm is provided with a vertical rotation supporting point. Also, the disk drive of the present invention ~~comprises~~ can comprise a recording medium with a recording medium layer formed on ~~the a~~ surface thereof, a rotating ~~means-device~~ for rotating the recording medium, and a head support device provided with a head slider with a head mounted on one end thereof and a driving ~~means-device~~ mounted on ~~the other another~~ end thereof, ~~wherein the~~. The head support device includes a support arm with a head disposed on one end thereof and an elastic member integrally formed along ~~the a~~ longitudinal center line near ~~the other another~~ end

thereof, a balancer fitted on ~~the other~~ another end of the support arm, and a first base arm having a projected coupling portion on one end thereof, and ~~the an~~ end portion of the elastic member is fixed on the first base arm, ~~and~~ the support arm or the first base arm is provided with a vertical rotation supporting point, and the head, opposing to the recording medium ~~of the head slider~~, is positioned apart from the vertical rotation supporting point in ~~the a~~ longitudinal direction of the support arm.

[0032] By using these configurations, a head support arm comprising a stable head support device can be realized, and it is possible to realize a disk drive which ensures high shock resistance and excellent reliability such as high-speed access.

[0033] Further, the head slider can be prevented from bumping against ~~the a~~ recording medium surface, or the bumping energy can be reduced, to prevent the head slider or the recording medium from being damaged even when great shock is applied to the head slider in a state of being afloat over the recording medium. Accordingly, it is possible to manufacture a head support device and a disk drive ensuring excellent reliability and also to mount a large-capacity, compact and thin disk drive in portable equipment.

BRIEF DESCRIPTION OF THE DRAWINGS

[0034] Fig. 1(a) is a side view showing ~~the a~~ general configuration of a head support device in ~~the a~~ first preferred embodiment of the present invention.

[0035] Fig. 1(b) is a plan view showing the general configuration of ~~a the~~ head support device in the first preferred embodiment of the present invention.

[0036] Fig. 2 is a perspective view showing ~~the a~~ configuration of ~~a the~~ head support device in the first preferred embodiment of the present invention.

[0037] Fig. 3 is an exploded perspective view showing the configuration of ~~a the~~ head support device in the first preferred embodiment of the present invention.

[0038] Fig. 4 is a side view of essential parts near ~~the a~~ bearing portion of ~~a the~~ head support

device in the first preferred embodiment of the present invention.

[0039] Fig. 5(a) is a perspective view from ~~the a surface opposing to recording medium~~ of a head slider, disposed on a head support device in the first preferred embodiment of the present invention, opposing a recording medium.

[0040] Fig. 5(b) shows the surface ~~opposing to recording medium~~ of a the head slider disposed on a the head support device in the first preferred embodiment of the present invention, opposing the recording medium.

[0041] Fig. 6 is a schematic diagram for describing ~~the~~ head slider displacement and an immovable point distance before and after application of shock to ~~the a~~ head slider.

[0042] Fig. 7(a) is a schematic diagram for describing ~~the~~ alteration of ~~the a~~ floating status with shock applied to the head slider in the first preferred embodiment of the present invention.

[0043] Fig. 7(b) is a schematic diagram for describing ~~the~~ alteration of ~~the a~~ floating status with shock applied to ~~the a~~ head slider of ~~the~~ comparative example 1.

[0044] Fig. 7(c) is a schematic diagram for describing ~~the~~ alteration of ~~the a~~ floating status with shock applied to ~~the a~~ head slider of ~~the~~ comparative example 2.

[0045] Fig. 8(a) is a plan view from ~~the a surface, opposing to a recording medium,~~ of a head slider having ~~another a different~~ recording medium opposing surface in than that of the first preferred embodiment of the present invention.

[0046] Fig. 8(b) is a plan view from ~~the a recording medium opposing surface~~ of a head slider having ~~further~~ another different surface, opposing to ~~a recording medium, than that of~~ in the first preferred embodiment of the present invention.

[0047] Fig. 8(c) is a plan view from ~~the a surface, opposing to a recording medium~~ of a head slider having a further ~~another different~~ surface, opposing to ~~the recording medium, than that of~~ in the first preferred embodiment of the present invention.

[0048] Fig. 9 is a diagram showing ~~the a~~ relationship between Lo/Ls value and shock resistance value.

[0049] ~~Fig. 10 (a), (b)~~ Figs. 10(a) and 10(b) are plan views showing ~~the~~ recording medium opposing ~~surface-surfaces~~ of a head ~~slider-sliders~~ used for the comparison with the shape of the surface, opposing ~~to a~~ recording medium, of the head slider in the first preferred embodiment of the present invention.

[0050] Fig. 11 is a side view of main parts showing ~~the a~~ configuration of a head support arm and a head support device in ~~the a~~ second preferred embodiment of the present invention.

[0051] Fig. 12 is a perspective view of main parts showing the configuration of ~~a the~~ head support arm and ~~a the~~ head support device in the second preferred embodiment of the present invention.

[0052] Fig. 13 is an exploded perspective view of main parts of ~~a the~~ head support arm in the second preferred embodiment of the present invention.

[0053] Fig. 14 is a side view for describing the action of ~~the a~~ balancer of the head support arm in the second preferred embodiment of the present invention.

[0053] Fig. 15 is a diagram for describing the operation of the head slider, with a shock load applied, in the second preferred embodiment of the present invention.

[0054] Fig. 16 is a diagram for describing the operation of the head slider, with ~~other~~ another shock load applied, in the second preferred embodiment of the present invention.

[0055] Fig. 17 is a plan view showing ~~the a~~ configuration of a head support device of a conventional magnetic recording and reproducing unit, and ~~the a~~ relationship between the head support device and ~~the a~~ magnetic recording medium.

[0056] Fig. 18 is a perspective view of essential parts showing a head support arm with a conventional head slider mounted thereon.

DETAILED DESCRIPTION OF THE INVENTION PREFERRED EMBODIMENTS

[0057] The preferred embodiments of the present invention will be described in the following with reference to the drawings.

(First preferred embodiment)

[0058] First, ~~the~~ a principle of operation of ~~the~~ a head support device in ~~the~~ a first preferred embodiment of the present invention is described by using a magnetic recording and reproducing unit as an example.

[0059] Fig. 1(a) is a side view showing ~~the~~ a general configuration of a head support device in the first preferred embodiment of the present invention, and Fig. 1(b) is a plan view of the same.

[0060] In ~~Fig. 1~~ Figs. 1(a) and 1(b), head slider 1 mounted with a magnetic head element (not shown) for recording and reproducing purposes is fitted on a surface, opposing ~~to the~~ recording medium 12, of support arm 2 so that the head element is opposed to the recording medium 12. As described later, the support arm 2 is supported by first bearing portion 10 and second bearing portion 11, which support arm is able to rotate radially of the recording medium 12 due to the first bearing portion 10 and is also able to turn vertically, making a so-called “up-and-down directional gate panel” motion, against ~~the~~ a surface of the recording medium 12 due to the second bearing portion 11.

[0061] The recording medium 12 is journaled on spindle motor 19 that is a rotating ~~means~~ device, and in ~~the~~ a recording or reproducing mode of the magnetic recording and reproducing unit, ~~that is,~~ with a magnetic head loaded, the magnetic head mounted on the head slider 1 executes a recording or reproducing operation, obtaining a specific amount of floatation against the recording medium 12, due to ~~the~~ a relationship between ~~the~~ buoyancy created by ~~the~~ air flow generated by ~~the~~ rotation of the recording medium 12 and ~~the~~ action of ~~the~~ head support device 9 which activates the head slider 1 toward the recording medium 12.

[0062] In ~~Fig. 1~~ Figs. 1(a) and 1(b), the support arm 2 of which the head slider 1 with ~~a~~ the magnetic head ~~device~~ disposed on ~~the~~ an underside thereof is mounted on ~~the~~ an underside of one end ~~thereof~~ of the support arm is fitted, at the ~~other~~ another end, to ~~a~~ one end portion of plate spring 4, which ~~that~~ is an elastic member as shown, and ~~the~~ other another end portion of the plate

spring 4 is fitted to the second bearing portion 11 via spring fixing member 5.

[0063] In this way, the support arm 2 is resiliently held on the second bearing portion 11 via the plate spring 4.

[0064] Also, the second bearing portion 11 is provided with a pair of pivots 11a and 11b (not shown), and the pivots 11a, 11b come ~~in~~into contact with the support arm 2 respectively at the points of Pa and Pb as shown in Fig. 1(b), and the one end portion of the support arm 2 is activated toward the recording medium 12 due to ~~the~~an elastic force of the plate spring 4 ~~that is an elastic member~~, thereby generating compressive stresses at contact points Pa and Pb. In case of no recording medium 12, the plate spring 4 will be deformed, causing the support arm 2 to be positioned as shown by dotted lines in Fig. 1(a).

[0065] The pivots 11a and 11b of the second bearing portion 11 are ~~vertical~~perpendicular to ~~the~~an axial direction of a rotational center with the support arm 2 rotated radially of the recording medium 12, are also perpendicular and to ~~the~~a longitudinal direction of the support arm 2, ~~which~~and are provided so as to come ~~in~~into contact with the support arm 2 on ~~the~~a line passing through the rotational center axis.

[0066] During operation of the magnetic recording and reproducing unit, or when the head slider 1 is ~~being~~ afloat against the recording medium 12, ~~the~~a load to the head slider 1 is generated by ~~the~~ compressive stress in ~~the~~a direction of the recording medium 12 to the support arm 2 due to the pivots 11a and 11b of the second bearing portion 11.

[0067] By using such a configuration of the head support device 9, the support arm 2 can be formed ~~with~~from a highly rigid material. Accordingly, it is possible to form the head support device 9 by using a highly rigid material over ~~the~~an entire range from the second bearing portion 11, the pivots 11a, 11b of the second bearing portion 11, and ~~the~~a region ~~supported by the second bearing portion 11~~ of the support arm 2 supported by the second bearing portion 11 to ~~the~~a region where the head slider 1 is formed.

[0068] In this way, the support arm 2 is formed ~~with~~from a highly rigid material, and ~~the~~a

resonance frequency of the support arm 2 can be enhanced. Accordingly, there is no generation of a vibration mode that has been a conventional problem, and no settling operation is required. As a result, ~~it enables~~ high-speed rotation and positioning of the support arm 2 is possible, and it becomes possible to improve ~~the~~ an access speed of the magnetic recording and reproducing unit.

[0069] Also, the plate spring 4 ~~that is an elastic member~~ is not built into the structure of the support arm 2, but rather is disposed independently of the support arm 2. Therefore, it is possible to select ~~the~~ a strength and spring constant of the plate spring 4 by changing ~~the~~ thickness, material or the like of the plate spring 4.

[0070] Also, in a configuration using the head support device 9, by designing the head support device in such manner that ~~the~~ a center of gravity of ~~the~~ a portion held by the plate spring 4 ~~that is an elastic member~~, for example, when rotated by a voice coil motor, ~~the~~ a center of gravity of the support arm 2 in a state of being fitted with a voice coil and coil holder, is substantially same in position as ~~the~~ a point of intersection between the rotational axis in the radial direction of the recording medium 12 of the support arm 2, ~~that is, the middle point P on the~~ a line connecting points Pa and Pb at which the support arm 2 comes in contact with the pivots 11a, 11b of the second bearing portion 11 (in Fig. 1(a), ~~the~~ a distance between P and Pa becomes equal to ~~the~~ a distance between P and Pb, ~~that which is~~ is L), it is possible to provide a head support device which is free from vibration and is stable. In this case, it is possible to provide a head support device maximized ~~in~~ with regard to shock resistance, but some difference causes no problem in actual use.

[0071] Further, as shown in Fig. 1(a), by supporting the head slider 1 with ~~the~~ flexure 13 formed on the support arm 2 via dimple 14 ~~formed on the~~ an underside at one end of the support arm 2, it is possible to realize a head support device which is flexible enough to follow unnecessary vibrations or the like in ~~the~~ a direction of pitch or roll of the head slider 1 against the recording medium 12 ~~of the head slider 1~~ during the operation of the magnetic recording and reproducing unit.

[0072] As described above, in the head support device of the present invention, incompatible requirements for increasing ~~the~~ load to the head slider, enhancing ~~the~~ flexibility, and further improving ~~the~~ rigidity of ~~the~~ structure can be satisfied independently of each other as individual component elements, and ~~the~~ design of the head support device is simplified and it is possible to remarkably expand ~~the~~ freedom of design.

5 [0073] Furthermore, in the head support device of the present invention, since ~~it requires~~ no forming (bending) is required of very accurate elastic members (such as a plate spring), unlike a conventional head support device, it is possible to manufacture a head support device by a simpler method as compared with the prior art.

[0074] ~~The operation~~Operation of the head support device of the present invention will be described in the following by using ~~Fig. 1~~Figs. 1(a) and 1(b).

10 [0075] As described above, when the recording medium 12 is stopping, the head slider 1 and the recording medium 12 are stopping in contact with each other, but as the recording medium 12 starts rotating for recording and reproducing operation, the head slider 1 is floated and the plate spring 4 ~~that is an elastic member~~ is deformed, causing the support arm 2 to ~~become~~attain an orientation as shown by solid lines in Fig. 1(a), so as to execute ~~the~~ magnetic recording and
15 reproducing operation, while keeping a specific clearance between the magnetic head and the recording medium 12.

[0076] In this case, ~~the a~~ reaction force of the plate spring 4 that acts to return the support arm 2 to ~~the a~~ state shown by dotted lines in Fig. 1(a) is ~~the a~~ load to be applied to the head slider
20 1.

[0077] ~~The~~This load can be varied by ~~changing the~~ material and thickness of the plate spring 4 ~~that is an elastic member~~, the height of the pivots 11a and 11b of the second bearing portion 11, or ~~the a~~ position in relation to of point G as shown in Fig. 1(a), which point corresponds to a ~~that is the~~ joint between the support arm 2 and the plate spring 4.

25 [0078] For example, the load applied will become greater if the plate spring 4 is formed

thicker by using a material of higher rigidity, and also, a greater load can be applied to the head slider 1 by heightening the pivots 11a and 11b of the second bearing portion 11 or by ~~making the position of~~ positioning point G ~~of the joint between the support arm 2 and the plate spring 4 in Fig. 1(a)~~ closer to point P.

[0079] Next, following ~~the~~ an operational principle of the head support device in the first preferred embodiment of the present invention, the configuration of the head support device of the present invention will be described in a little more detail.

[0080] Fig. 2 is a perspective view showing ~~the~~ a configuration of the head support device in the first preferred embodiment of the present invention. Fig. 3 is an exploded perspective view of the head support device in the first preferred embodiment of the present invention. Fig. 4 is a side view of essential parts near the bearing ~~portion~~ portions of the head support device in the first preferred embodiment of the present invention.

[0081] As shown in Fig. 2 and Fig. 3, the head support device 9 is configured ~~in~~ such that a nearly annular plate spring (elastic member) 4 and a semi-circular annular spring fixing member 5 are connected to each other, and the plate spring 4 is also connected to the support arm 2. The support arm 2 is connected to ~~the~~ a coil holder 8 fitted with voice coil 3 in such manner that ~~it~~ the support arm can be rotated in ~~the~~ a radial direction of the recording medium 12 by ~~means~~ virtue of ~~the~~ a voice coil motor. These members are held between the bearing portion 10 and a nut 6 together with the second bearing portion 11.

[0082] Also, as shown in Fig. 4, ~~the whole of~~ the head support device 9 in its entirety is fastened to substrate 15 by ~~means~~ virtue of a screw 7 of the bearing portion 10.

~~The connection~~ Connection of each member will be described in further detail by using Fig. 4. First, at the right-hand side of the rotational axis in ~~the~~ this figure, ~~the~~ a top surface of the plate spring 4 (elastic member) is connected with ~~the~~ an underside of the support arm 2, and at the left-hand side thereof, the plate spring 4 and the spring fixing member 5 are held between the bearing portion 10 and nut 6 together with ~~the~~ a collar 11c of the second bearing

portion 11. Also, the support arm 2 is fitted ~~on~~onto the coil holder 8.

[0084] By using such a configuration, it is possible to realize a configuration in which the plate spring 4 ~~that is an elastic member~~ deforms so as to bend in two steps as shown in Fig. 4, thereby resiliently retaining the support arm 2.

[0085] Also, the bearing portion 10 is equipped with a bearing so that the support arm 2 may rotate in the radial direction of the magnetic recording medium in order to move the magnetic head disposed on the underside at one end ~~thereof of the support arm~~ to a predetermined position.

[0086] The pivots 11a and 11b of the second bearing portion 11 are ~~vertical-perpendicular~~ to the ~~an~~ axial direction of the bearing portion 10 and also to the longitudinal direction of the support arm 2, which pivots are disposed so as to come in-into contact with the support arm 2 on the line passing through the rotational center ~~in the radial direction of the magnetic recording medium of the bearing portion 10 of the support arm~~.

[0087] Further, the pivots 11a and 11b of the second bearing portion 11 are disposed in positions symmetrical to ~~the a~~ center line in the longitudinal direction of the support arm 2, and the support arm 2 is pushed ~~downward~~downwardly by the ~~pair of~~ pivots 11a, 11b.

[0088] Also, by designing the head support device 9 in such manner that the center of gravity of the portion held by the plate spring 4 ~~that is an elastic member~~, that is, the center of gravity of the support arm 2 in a state of being fitted with voice coil 3 and coil holder 8, is substantially same in position as the middle point P on the line connecting points Pa and Pb at which the support arm 2 comes in-into contact with the pivots 11a, 11b of the second bearing portion 11 (as shown in Fig. 1(a), the distance between P and Pa becomes equal to the distance between P and Pb, ~~that which is L~~), it is possible to provide a head support device which is stable and less influenced by external vibration or the like. In this case, it is possible to provide a head support device maximized in terms of shock resistance, but some difference causes no problem in actual use.

[0089] Also, taking into account ~~the~~ weight of the head slider 1 and flexure 13, it is also

preferable to form the head support device 9 so that the center of gravity of the support arm 2 in a state of being fitted with the voice coil 3, coil holder 8, head slider 1 and flexure 13 is substantially same in position as ~~the~~ point P.

[0090] Each of these members will be described in the following. First, the support arm 2 is integrally formed so as to be 64 μm in thickness by using a metal, for example, stainless steel (SUS304). An etching process or press machining process can also be employed for forming the support arm 2.

[0091] By using ~~the~~ a support arm 2 formed in this way, ~~the~~ resonance frequency of its twisting can be greatly increased from about 2 kHz, a conventional level, to about 10 kHz. Accordingly, it is possible to obtain a magnetic recording and reproducing unit of which ~~the~~ rotational speed and access speed of the head support device are very high.

[0092] By using such support arm 2, ~~the~~ resonance frequency of its bending can be greatly increased from about 200 Hz, a conventional level, to about 2 kHz. Accordingly, it is possible to obtain a magnetic recording and reproducing unit of which ~~the~~ rotational speed and access speed of the head support device are very high.

[0093] As a result, it is possible to suppress ~~the~~ bending and deformation of the support arm 2 when shocks are applied thereto, and to prevent the support arm 2 from bumping against ~~the~~ a recording medium.

[0094] It is also preferable to provide a bend of about 0.2mm in height in a direction ~~vertical~~ perpendicular to ~~the~~ a recording surface of ~~the~~ a recording medium in order to increase ~~the~~ longitudinal rigidity in ~~the~~ a region, shown by C in Fig. 2, of ~~the~~ an end portion of the support arm 2.

[0095] Also, in Fig. 3, the head slider 1 is supported by flexure 13 in such manner as to be able to incline in ~~the~~ a direction of roll and pitch via a dimple (not shown in Fig. 3), and there is provided a magnetic head on the surface of the head slider 1 opposing ~~to~~ the recording medium ~~of the head slider 1~~.

[0096] The spring fixing member 5 is formed to be 0.1 mm in thickness by using a metal, for example, stainless steel (SUS304), and the plate spring 4 ~~that is an elastic member~~ is formed to be 38 μ m in thickness by using a metal, for example, stainless steel (SUS304). An etching process or press machining process can also be employed for forming these members.

[0097] Also, the coil holder 8 is formed to be 0.3 mm in thickness by using a metal, for example, Al or PPS (polyphenylsulfide). In the case of Al, a die casting process or press machining process can be employed for forming the coil holder, and in the case of PPS, a well-known resin forming process can be employed for forming the coil holder.

[0098] Also, for ~~the~~ connection of each member, a spot welding process, supersonic welding process, laser beam machining process and the like can be employed.

[0099] The present invention is not limited at all with respect to the manufacturing method of each member or the method of ~~connection between~~ connecting the members.

[0100] By using the configuration as described above, it is possible to provide a head support device which ~~may materialize~~ exhibits the principle as shown in the first preferred embodiment.

[0101] Also, by configuring the head support device 9 in this way, it is possible to realize a novel operation that has never been seen in any prior art because the support arm 2 fulcrumed on the pivots 11a and 11b of the second bearing portion 11 is able to freely rotate in a direction ~~vertical-perpendicular to the~~ a recording surface of the recording medium.

[0102] For example, in a CSS type magnetic recording and reproducing unit, the prior art was unable to freely move the support arm in a vertical direction, and it was necessary to prevent the head slider from being attracted to ~~the~~ a recording medium in a stop mode. However, according to the head support device of the present invention, the support arm can be vertically operated by a well-know ~~means~~ device, and it is possible to keep the support arm ~~a little apart~~ slightly spaced from ~~the~~ a recording medium while the magnetic recording and reproducing unit is in a stop mode. Accordingly, it is unnecessary to provide the recording medium with a region

in which the magnetic head may take shelter.

[0103] Also, in an L/UL type magnetic recording and reproducing unit, the support arm can be vertically operated by a well-know ~~means~~ device, and it is possible to keep the support arm a ~~little apart~~ slightly spaced from ~~the a~~ a recording medium while the magnetic recording and reproducing unit is in a stop mode. Accordingly, it is possible to minimize ~~such a~~ wasteful region of the magnetic recording medium ~~that at which~~ the magnetic head is loaded and unloaded as in the prior art.

[0104] Next, the head slider of the head support device in the preferred embodiment of the present invention will be described.

[0105] Fig. 5(a) and Fig. 5(b) show a perspective view from ~~the a~~ a surface opposing to ~~the a~~ a recording surface of the head slider mounted on the head support device in the first preferred embodiment of the present invention, and ~~the a~~ a surface opposing to ~~a~~ a recording medium thereof. Head slider 20 is provided with a surface opposing to 26 that opposes a recording medium 26, ~~opposed to the recording medium, on a which~~ surface of is generally rectangular in shape. The ~~recording medium opposing surface~~ 26 comprises positive pressure generator 21, lower stage 22 including negative pressure generator 221, first middle stage 23 formed so as to connect ~~from the~~ an air inflow end to ~~the a~~ a first positive pressure generator 211, and second middle stage 24 disposed so as to extend in ~~the an~~ an air inflow direction from ~~the a~~ a second positive pressure generator 212.

[0106] The positive pressure generator 21 comprises the first positive pressure generator 211, side rails 213 formed on either widthwise side of the head slider so as to ~~connect~~ be connected to the first positive pressure generator 211, and the second positive pressure generator 212, which has a ~~formed in~~ hexagonal shape as shown, at ~~the a~~ a widthwise center perpendicular to ~~the a~~ a direction of a spindle that is ~~the~~ the direction of air flow at ~~the an~~ an air outflow side. The first positive pressure generator 211 ~~is formed in a range~~ extends continously from ~~the an~~ an air inflow end to a predetermined position ~~continously that is spaced~~ from the an end of the first middle stage 23,

~~which is formed of~~ and has a portion that is perpendicular to the ~~an~~ air inflow direction and also has a slanted portion for connecting the perpendicular portion to each of the side rails 213. The lower stage 22 comprises the negative pressure generator 221, which is almost surrounded by the first positive pressure generator 211, side rails 213, and the second middle stage 24~~7~~. The lower stage 22 also comprises side lower stage 222 positioned outwardly of the side rails 213, and air outflow side lower stage 223 disposed at ~~the~~ an air outflow side. ~~The~~ An information conversion element 25 is integrally arranged at ~~the~~ an air outflow end of the second positive pressure generator 212.

[0107] ~~These manufacturing~~ Manufacturing processes can be executed by a method of head slider forming or general machining as well, but it is preferable to employ a wet or dry etching process or, in case of highly accurate and complicated machining, to use a method of machining by laser beam application, ion application ~~and or~~ the like.

[0108] In the first preferred embodiment, by ~~using a method of~~ performing an ion application process, ~~the a~~ level difference between the positive pressure generator 21, the first middle stage 23, and the second middle stage 24 is set to 0.08 μm , and ~~the a~~ level difference between the positive pressure generator 21 and the lower stage 22 including the negative pressure generator 221 is set to 1.0 μm . As ~~the an~~ overall shape of the head slider 20, ~~the length in the a~~ direction of air flow, and ~~the a~~ widthwise length and thickness at right ~~angle~~ angles to the direction of air flow are respectively 1.24 mm, 1.00 mm and 0.3 mm. Incidentally, these values are mentioned as an example, and the present invention is not limited to this example.

[0109] Further, for ~~the~~ comparison with the head slider in the first preferred embodiment, a head ~~slider~~ sliders shaped as shown in ~~Fig. 10~~ Figs. 10(a) and 10(b) were ~~was~~ also manufactured as ~~trial~~ trials. ~~The elements~~ Elements with same functions and names as those shown in Fig. 5 are given same reference numerals, and ~~the~~ description thereof is omitted. In Fig. 10(a), ~~the a~~ head slider ~~shown in (a)~~ 70 is called comparative example 1, and ~~the a~~ head slider 80 shown in Fig. 10(b) is called comparative example 2. Head slider 70, comparative example 1, comprises

~~the~~a first positive pressure generator 71 with ~~the~~a central portion separated at ~~the~~an air inflow side, ~~the~~a second positive pressure generator 72 formed so as to be surrounded by ~~the~~a second middle stage 74 at ~~the~~an air outflow side, and ~~the~~a negative pressure generator 221 disposed between the first positive pressure generator 71 and the second positive pressure generator 72. The first positive pressure generator 71 connects to ~~the~~a first middle stage 73 extending from ~~the~~an air inflow end, which also has side rails in ~~the~~a widthwise direction and is connected to ~~the~~a third middle stage 75 that is L-shaped. The second positive pressure generator 72 is surrounded by the second middle stage 74 disposed at the air outflow side, and ~~the~~an information conversion element 25 is formed at ~~the~~an air outflow end of the second positive pressure generator 72. The negative pressure generator 221 is surrounded by the first middle stage 73, the second middle stage 74, the third middle stage 75, and the first positive pressure generator 71. Side lower stage 222 is disposed at ~~the~~ widthwise sides of the head slider 70, and air outflow side lower stage 223 is arranged at ~~the~~ sides of the air outflow side in the same way as for the head slider 20 in the first preferred embodiment.

[0110] Also, the head slider 80, comparative example 2, comprises a stripe-like first positive pressure generator 81 formed so as to be held between ~~the~~a third middle stage 82 ~~formed in~~ having a \sqsupset -shape and ~~the~~a first middle stage 23 which is flush with the third middle stage 82, and ~~the~~a negative pressure generator 221 is continuous with the third middle stage 82 and is formed to be smaller in area. ~~The others~~ Others are same in shape as the head slider 20 in the first preferred embodiment.

[0111] Regarding the head slider 20 in the first preferred embodiment, and the head sliders 70, 80 of comparative example 1 and comparative example 2, ~~the~~an immovable point is obtained from air layer rigidity, followed by obtaining ~~the~~a maximum shock generated due to coming in into contact with ~~the~~a recording medium when a shock is applied in ~~the~~a direction toward the recording medium, for ~~the~~a purpose of evaluating ~~the~~ shock resistance. In ~~the~~ evaluation of shock resistance, ~~the~~an equivalent mass including the head slider and ~~the~~ head slider holding

section is 1 mg, ~~the a~~ load from the support arm is 2 gf, ~~the a~~ recording medium rotating speed is 4,500 rpm, and ~~the a~~ skew angle at 6 mm radially of the recording medium is - 5 degrees.

[0112] Further, the immovable point obtained from air layer rigidity is described by using Fig. 6. ~~The A~~ state of head slider 30 being afloat over ~~the~~ recording medium 12 by pitch angle θ_p and ~~the an~~ amount of floatation X_t at ~~the an~~ air outflow end is shown by solid lines, and ~~the a~~ state of head slider 30a being displaced ~~by vertical displacement~~ vertically a distance x and ~~angular displacement~~ angularly displaced an angle θ due to impact force F applied to the head slider 30 is shown by chain lines. Immovable point G is shown by ~~the an~~ intersection of the extended lines of the head slider 30 in a steady state of being afloat and the head slider 30a after being displaced by ~~sheeks~~ impact force F, as shown in Fig. 6. ~~The action~~ Action point P1 of load is ~~the a~~ center of head slider 30 in ~~the a~~ direction of air flow, to which ~~the a~~ load from a support arm (not shown) is also applied.

[0113] ~~The A~~ center of ~~the a~~ surface of the head slider 30 opposing to recording medium 12 ~~of the head slider 30~~ rotates about ~~the center of~~ immovable point G from P1 in a steady state of being afloat to ~~the position of~~ P2 after displacement. Distance L_o from ~~the action point~~ P1 to the immovable point G can be obtained by formula (1) because θ_p is very small and can be considered to be $\cos \theta_p = 1$.

$$L_o = \frac{x}{\theta} \quad (1)$$

[0114] On the other hand, when the displacement against impact force F from outside is the rotation ~~around the load action~~ about point P1 and the translation ~~motion~~ of ~~the action point~~ P1 toward the recording medium 12, ~~then it distane~~ L_o can be represented by the following formula where the displacement in a direction ~~vertical-perpendicular~~ to the recording medium 12 from the ~~action point~~ P1 of the load to the head slider 30 is x , and the rotation is θ .

$$\begin{bmatrix} k_{11} & k_{12} \\ k_{21} & k_{22} \end{bmatrix} \begin{bmatrix} x \\ \theta \end{bmatrix} = \begin{bmatrix} F \\ 0 \end{bmatrix} \quad (2)$$

[0115] In this formula, k_{11} , k_{12} , k_{21} , and k_{22} are the coefficients of rigidity of an air layer of the head slider 30, and k_{11} is vertical rigidity, k_{22} is rotational rigidity, and k_{12} and k_{21} are respectively ~~the~~ a coefficient of force in ~~the~~ a rotating direction generated when the head slider 30 moves in a direction ~~vertical-perpendicular~~ to the recording medium 12 and ~~the~~ a coefficient of force in the ~~vertical-perpendicular~~ direction generated due to ~~the~~ rotational movement. Formula (3) can be obtained by rearranging the formula as follows.

$$\begin{bmatrix} x \\ \theta \end{bmatrix} = \frac{1}{\Delta} \begin{bmatrix} k_{11} & -k_{12} \\ -k_{21} & k_{22} \end{bmatrix} \begin{bmatrix} F \\ 0 \end{bmatrix} = \frac{1}{\Delta} \begin{bmatrix} k_{22} & F \\ -k_{21} & F \end{bmatrix} \quad (3)$$

[0116] Accordingly, ~~the~~ distance L_o of ~~the~~ immovable point can be obtained from formula (1) and formula (3) as ~~the~~ a ratio of rotational rigidity k_{22} of air layer to the coefficient of force k_{21} in the ~~vertical-perpendicular~~ direction generated due to ~~the~~ rotational movement, as shown in formula (4).

$$L_o = \frac{x}{\theta} = -\frac{k_{22}}{k_{21}} \quad (4)$$

[0117] The rigidity coefficients k_{22} and k_{21} can be precisely obtained once ~~the~~ a shape of the surface of the head slider 30 opposing to recording medium 12 ~~of the head slider 30~~, recording medium rotating speed, equivalent mass and the like are determined, and from ~~the~~ a value then obtained, ~~the~~ distance to ~~the~~ immovable point L_o can be prescribed.

[0118] Obtaining ~~the~~ distance L_o to ~~the~~ immovable point G from the ratio of the above rigidity coefficients, normalized L_o/L_s as against ~~the~~ length L_s of head slider 30 and ~~the~~ result results of shock resistance are shown in Table 1. ~~The length~~ Length L_s of head slider 30 is a

length parallel to the recording medium 12 surface, which differs from ~~the~~an actual length of head slider 30, but it can be regarded as being substantially the same because θ_p is very small and can be considered to be $\cos \theta_p = 1$.

	Lo/Ls	Shock resistive value: G
1st embodiment	0.9	8000
Example 1	3.6	2080
Example 2	0.45	4560

[0119] As is obvious ~~in~~from Table 1, in the head slider 20 of the first preferred embodiment, the value of Lo/Ls is 0.9, and the value of shock resistance is about 8000G. On the other hand, in the head slider 70 of Example 1, the value of Lo/Ls is 3.6, and the value of shock resistance is 2080G in combination with a conventional support arm, while in the head slider 80 of Example 2, the value of Lo/Ls is 0.45, and the value of shock resistance is about 4560G. Regarding ~~the~~these results, ~~the~~ description will be given by using ~~the~~ schematic diagrams shown in Fig. 7 Figs. 7(a)-7(c). The head slider 20 of the first preferred embodiment shown in Fig. 7(a) is floating with floating clearances of Z1 and Xt, respectively created at ~~the~~an air inflow end and an air outflow end, against ~~the~~a surface of ~~the~~ recording medium 12. In this condition, when impact force F is applied to the head slider 20, ~~it~~ the head slider is displaced to ~~the~~a position shown by head slider 20a, but ~~the~~an amount of displacement at the air outflow end is smaller as compared with ~~the~~an amount of displacement of ~~the~~ floating clearance at the air inflow end. If a shock greater than the impact force F is applied, ~~it~~ the head slider will be displaced to ~~the~~a position shown by head slider 20b, but even in such condition, the head slider will still maintain a normal pitch angle, and therefore, ~~the~~an air layer will not be affected and may act as spring to prevent the head slider from bumping against the recording medium. Or even when ~~it~~such bumping is not completely prevented, damage will hardly take place because ~~the~~ bumping energy is very little. ~~The~~A reason for this is that, in the head slider 20 of the first preferred embodiment, the surface of the

head slider opposing ~~to~~ recording medium 12 ~~of the head slider 20~~ is formed so as to be positioned in a space where the distance L_0 ~~to the immovable point~~ is nearly equal to ~~the~~ a length of the head slider 20.

[0120] The schematic diagram of the head slider 70 of Example 1 is shown in Fig. 7 (b). When impact force F is applied to the head slider 70 of Example 1, ~~it the head slider~~ is displaced to ~~the~~ a position shown by the head slider 70a. ~~The displacement~~ Displacement takes place this way because the immovable point G_2 is positioned in a space that is 3.6 times as far away as compared with ~~the~~ a length of the head slider 70. Namely, when the immovable point is positioned like this, the impact force F causes almost no rotation in ~~the~~ a direction of pitch, resulting in generation of nearly ~~vertical~~ perpendicular movement, and therefore, a relatively low impact force causes ~~the~~ an air outflow end to bump against the recording medium 12.

[0121] The schematic diagram of the head slider of Example 2 is shown in Fig. 7(c). In the case of the head slider 80 of Example 2, ~~the~~ a ratio of L_0/L_s is 0.45, and immovable point G_3 is positioned a little closer to ~~the~~ an action point than to ~~the~~ an air outflow end. Accordingly, even if the head slider is displaced to ~~the~~ a position shown by head slider 80a due to impact force F , ~~it~~ the head slider will not bump against the recording medium 12, which is therefore improved in terms of shock resistance as compared to the head slider 70 of Example 1. However, when a ~~shock force~~ is further applied, as shown by head slider 80b, ~~the~~ a floating clearance at ~~the~~ an air inflow side becomes less as compared with ~~the~~ a floating clearance at ~~the~~ an air outflow side, thereby forming no air layer. In ~~that~~ this case, no buoyancy is created, and the head slider 80 bumps against a surface of the recording medium 12 ~~surface~~, thereby causing the head slider 80 or the recording medium 12 to be damaged. ~~The~~ A value of shock resistance that causes ~~the~~ a floating clearance at the air inflow side to become less as compared with the air outflow side varies with not only ~~the~~ a shape of the surface of the head slider opposing ~~to~~ a recording medium but also ~~the~~ with variation of the rotating speed and ~~the~~ alteration of ~~the~~ a skew angle, or ~~the~~ with variation of load and the like. Also, when lessening a the floating clearance ~~becomes less~~, it will

rapidly lead to damage, thereby increasing ~~the~~ a variation of the shock resistance value.

[0122] Regarding ~~the~~ a relationship between Lo/Ls value and a shock resistance value, ~~the~~ these values have been obtained with respect to various head sliders having different shapes of the surface opposing ~~to~~ recording medium 12. In ~~Fig. 8~~ Figs. 8(a)-8(c), three types of shapes of ~~the~~ a surface opposing ~~to~~ recording medium 12 are shown. ~~The names~~ Names that correspond to the elements and functions shown in Fig. 5 are given same reference numerals, and ~~the~~ description thereof is omitted. ~~The~~ A head slider 40 (hereafter referred to as type A) of Fig. 8(a) includes ~~the~~ a first positive pressure generator 41 that is stripe-formed and held between ~~the~~ a first middle stage 23 extended from ~~the~~ an air inflow side and ~~the~~ a third middle stage 42 having side rails at either widthwise side thereof. ~~The differences~~ Differences from the head slider 20 in the first preferred embodiment shown in Fig. 5 are that the first positive pressure generator 41 is wide and stripe-formed ~~and widely formed~~ at a position close to the air inflow side and that ~~the~~ negative pressure generator 221 is mainly surrounded by the third middle stage 42. Therefore, in type A, ~~the~~ positive pressure generated at the first positive pressure generator 41 is positioned a little closer to the air inflow side as compared with the head slider 20 shown in Fig. 5.

[0123] Also, ~~the~~ a head slider 50 (hereafter referred to as type B) of Fig. 8(b) is such that ~~the~~ a first positive pressure generator 51 is stripe-formed and held between ~~the~~ a first middle stage 23 and ~~the~~ a third middle stage 52 ~~formed in~~ having a \sqsupset -shape, and ~~the~~ a negative pressure generator 221 is formed in a region surrounded by the third middle stage 52, and ~~the~~ others are same in shape as those of the head slider 20 shown in Fig. 5. Therefore, in type B, ~~the~~ positive pressure generated at the first positive pressure generator 51 is positioned a little closer to the air inflow side as compared with the head slider 20 shown in Fig. 5, and also, ~~the~~ rigidity of an air layer at ~~the~~ this portion is a little lower.

[0124] Further, ~~the~~ a head slider 60 (hereafter referred to as type C) of Fig. 8(c) is such that ~~the~~ a first positive pressure generator 61 is shifted to ~~the~~ an air inflow side to enlarge ~~the~~ a region of ~~the~~ a negative pressure generator 221, and ~~the~~ side rails disposed at either side become ~~the~~ a

third middle stage 62 in ~~the~~ a middle thereof, and ~~the~~ others are same in shape as the head slider 20 shown in Fig. 5. Therefore, in type C, ~~the~~ positive pressure generated at the first positive pressure generator 61 is positioned a little closer to the air inflow side as compared with the head slider 20 shown in Fig. 5, and ~~the~~ negative pressure generated at the negative pressure generator 221 is also positioned a little closer to the air inflow side.

[0125] ~~The~~ Lo/Ls values and shock resistance values of these three types of head sliders are shown in Table 2.

	Lo/Ls	Shock resistive value: G
Type A	0.7	7200
Type B	1.6	6960
Type C	1.8	6400

[0126] As is obvious ~~in the~~ from this table, the Lo/Ls value is in a range from 0.7 to 1.8, and the shock resistance value ranges from 6400G to 7200G.

[0127] Fig. 9 is ~~the~~ a result of obtaining ~~the~~ a relationship between the Lo/Ls value and the shock resistance value with use of a head slider having a differently shaped ~~different shape of~~ surface opposing ~~to~~ a recording medium. As is apparent ~~in from~~ Fig. 9, when the Lo/Ls value is 0.5 or less, the shock resistance value abruptly lowers, and also, ~~the~~ variation of the shock resistance value increases in this range. This is because, as described above, when the immovable point is positioned more ~~inward~~ inwardly than ~~the is an~~ air outflow end of ~~the~~ a head slider, ~~the~~ a floating clearance becomes less at the air inflow end. Therefore, the Lo/Ls value is desirable to be larger than 0.5. On the other hand, when the Lo/Ls value is 1 or ~~over~~ more, the shock resistance value is almost linearly reduced. As a shock resistance value required for mounting ~~the~~ a disk drive in portable equipment, it is necessary to ~~make the~~ have this value be 750G or ~~over~~ more, and as an Lo/Ls value, it is desirable to ~~make the~~ have this value be 2 or less.

Judging from these results, it is possible to realize a disk drive which can be mounted in portable

equipment by using a head slider having a surface shape opposing to a recording medium such that the L_o/L_s value is larger than 0.5 and less than 2.

[0128] Further, since the negative pressure (the a force by which the a head slider is attracted to the a recording medium) generated on the an air lubricated surface of the head slider in the present preferred embodiment is about 2.5 gf, and the a load from the support arm is 2 gf, the head slider does not jump from the recording medium even when it the head slider is moved
5 apart from the recording medium with a force of 3.5 gf. The An equivalent mass of the support arm of the present preferred embodiment is 1 mg, and therefore, the head slider does not jump from the recording medium even when subjected to an impact acceleration of 3500G, thereby preventing the recording medium from being seriously damaged by the head slider jumping and
10 then bumping against the recording medium.

[0129] Also, in the above example of the shape of a head slider, the length (L_s) in the direction of air flow is 1.24 mm. Judging from the above description and the results shown in Table 1, Table 2 and Fig. 9, L_s is desirable to be in within the range of $0.2\text{mm} < L_s < 1.4\text{mm}$. Lower limit 0.2mm is limited by the a size of an information conversion element, and upper
15 limit 1.4mm is limited by the a desirable mass of the head slider. Also, when the a distance from the a center of the head slider to the its rotational center is L_k , it establishes established is the relation relationship of $0.5L_s < L_k < 2L_s$. And L_k is desirable to be in within the range of $0.3\text{mm} < L_k < 2.0\text{mm}$. This range of L_k is limited by the lower limit value of L_s and the desirable mass of the head slider.

[0130] In the present preferred embodiment, described is the case of applying a load from
20 the support arm, but the present invention is also preferable to be configured in that only the mass of the head slider itself is applied as a load, and in this case, the an action point of the load corresponds to the a center of gravity of the head slider. Also, it is preferable that the load from the support arm acts on a position other than the center of gravity of the head slider, and in this
25 case, the action point of the load is preferable to be at the a balancing position between the load

from the support arm and the center of gravity of the head slider.

[0131] Also, in the present preferred embodiment, it is intended to obtain ~~the a~~ position of the immovable point from two movements such as in ~~the a~~ direction vertical-perpendicular to the a recording medium and in ~~the a~~ direction of pitch with respect to ~~the~~ movement of the head slider, but it is also preferable to obtain the position including ~~the~~ movement in ~~the a~~ direction of roll as in the following formula.

$$\begin{pmatrix} x \\ \theta \\ \phi \end{pmatrix} = \begin{pmatrix} k_{11} & k_{12} & k_{13} \\ k_{21} & k_{22} & k_{23} \\ k_{31} & k_{32} & k_{33} \end{pmatrix} \begin{pmatrix} F \\ 0 \\ 0 \end{pmatrix}$$

(Second preferred embodiment)

[0132] ~~The A~~ head support device in the second preferred embodiment of the present invention will be described in the following. ~~The remarkable~~ Remarkable differences of the head support device in the second preferred embodiment of the present invention from that in the first preferred embodiment described above are that the head support device comprises a second base arm of high rigidity provided with a first bearing portion, and a second bearing portion using a pivot positioned apart from the first bearing portion, which also includes a head support arm comprising a support arm formed of a thin member such as SUS and a first base arm. The head support arm in the second preferred embodiment is mainly related with ~~the~~ rotational operation in a direction vertical-perpendicular to ~~the a~~ surface of ~~the a~~ magnetic recording medium.

[0133] The head support device in the second preferred embodiment of the present invention will be described in the following with reference to the drawings. Fig. 11, Fig. 12, and Fig. 13 are diagrams for describing the head support arm and the head support device in the second preferred embodiment of the present invention. Fig. 11 is a side view of main parts, showing ~~the~~ a configuration of the head support arm and the head support device. Fig. 12 is a perspective

view of the main parts, and Fig. 13 is an exploded perspective view of main parts of the head support arm. As an example of a disk drive, a magnetic recording and reproducing unit is described the same as in the first preferred embodiment.

[0134] In Fig. 11, Fig. 12, and Fig. 13, head slider 1 mounted with a magnetic head (not shown) is fixed on flexure 13, for example, integrally provided with a metal sheet such as SUS and a flexible wiring board, that is, a so-called gimbals mechanism, ~~and further, the~~ The flexure 13 is fixed on support arm 2, and ~~the~~ a peak of dimple 14 disposed on the support arm 2 abuts the flexure 13 in such manner that the head slider 1 fixed on the flexure 13 is able to freely move about the peak of the dimple 14. The support arm 2 is provided with plate spring 4 that is an elastic member which is tongue-shaped by cutting away a part of ~~the~~ an area close to ~~the~~ a longitudinal center line 96, and one end of the tongue-shaped plate spring 4 is secured on first base arm 91 by a well-known method such as spot welding, supersonic welding, or laser beam welding process. The plate spring 4 is preferable to be formed of ~~other~~ another material member that is different from the support arm 2, and in the case of using ~~other~~ another material member, one end of the material member to become the tongue-shaped plate spring 4 is fixed on the support arm 2, and ~~the other~~ another end is fixed on the first base arm 91 by ~~the~~ an above well-known welding process or a like method. Also, the first base arm 91 is provided with two pivots 11a, 11b at positions symmetrical to the longitudinal center line 96 of the support arm 2, and ~~the~~ respective peaks of these pivots 11a, 11b are abutting the support arm 2. Accordingly, it is configured ~~in~~ that the support arm 2 fulcrumed on the respective peaks of the two pivots 11a, 11b of the first base arm 91 is turned against ~~the~~ an elastic force of the plate spring 4, and thereby, the head slider 1 is activated toward ~~the~~ a recording medium in such manner that the head slider 1 fixed on the support arm 2 presses ~~the~~ a surface of the recording medium (not shown in Fig. 12, 13). Further, ~~the other~~ another end of the first base arm 91 is formed with coupling portion 92 made up of a hollow cylindrical projection or the like for ~~the purpose of~~ integration with the second base arm 94. Also, a balancer is fixed on ~~the other~~ another end (opposite end of head

slider 1 with pivot 11a therebetween) of the support arm 2 so that ~~the~~a center of gravity of the head slider 1, flexure 13 and support arm 2 in ~~the~~a direction of the recording medium ~~of the head slider 1, flexure 13 and support arm 2~~ passes through ~~the~~a line that connects the respective peaks of the two pivots 11a, 11b of the first base arm 91, on which the support arm 2 is fulcumed. The head support arm 90 comprises the head slider 1 mounted with a magnetic head, the flexure 13, the support arm 2 having plate spring 4 ~~that is an elastic member~~, the first base arm 91, and the balancer 93. As the balancer 93, it is preferable to electrically construct ~~the~~this mechanism by using an amplifier circuit or the like.

[0135] Also, the plate spring 4 ~~that is an elastic member~~ is formed by cutting away a part of the area close to the longitudinal center line 96 of the support arm 2, and both ~~the~~ right and left sides of the support arm 2 are continuous in shape generally over ~~the~~an entire region in the longitudinal direction. Accordingly, side reinforcement 95 can be disposed by bending each of the right and left sides generally over the entire region. By providing the side reinforcement 95 for the support arm 2, ~~the~~ rigidity of the support arm 2 can be greatly increased and ~~the~~ resonance frequency of the support arm 2 can be greatly increased from about 2 kHz, conventional level, to about 10 kHz. Therefore, ~~the~~a rotating speed of the head support arm 90 can be very much increased and it becomes possible to greatly increase ~~the~~ access speed.

[0136] The second base arm 94 has a hole portion for fastening the first base arm 91 at one end thereof, in which the first base arm 91 having the head slider 1 is fastened by a well-know method such as caulking. As a disk drive, there is provided ~~the~~a first bearing portion 10, and a driving ~~means~~device such as a voice coil motor 18 at ~~the~~an opposite side of the first base arm 91 with the first bearing portion 10 therebetween. ~~The head~~ Head support device 9 comprises the head support arm 90 and the second base arm 94, and therefore, ~~the~~a length of ~~the~~an arm portion of either the first base arm 91 or the second base arm 94 of the head support arm 90 can be changed in accordance with ~~the~~ size of ~~the~~a recording medium, and it is possible to obtain a practical configuration to cope with ~~the~~ standardization in ~~the~~ manufacture of magnetic recording

and reproducing units having recording mediums of various sizes and types.

[0137] ~~The~~ A push force with which the head slider 1 pushes ~~the~~ a surface of ~~the~~ a recording medium can be freely set in accordance with ~~the~~ material and thickness of the plate spring 4 ~~that is an elastic member~~, the height of each peak of the two pivots 11a, 11b, and ~~the~~ a position of ~~the~~ a connection or fixed portion of the support arm 2 and the plate spring 4. For example, a great activating force can be applied by thickly forming the plate spring 4 with a material of high rigidity. Or, a great activating force can also be applied by increasing the height of each peak of the two pivots 11a, 11b.

[0138] Next, the balancer 93 mentioned above is described by using Fig. 14. With reference to ~~the~~ a rotational axis that connects the respective peaks of the two pivots 11a, 11b disposed on the first base arm 91, suppose ~~the~~ a distance to ~~the~~ a center of gravity of head slider 1 is L_1 , ~~the~~ a distance to ~~the~~ a center of gravity of balancer 93 is L_2 , ~~the~~ mass of head slider 1 is M_1 , ~~the~~ mass of balancer 93 is M_2 , ~~the~~ total mass obtained by adding ~~the~~ a mass of ~~the~~ a rotating portion of support arm 2 to ~~the~~ a mass of flexure 13 is M_3 , and ~~the~~ a distance to ~~the~~ a center of gravity subjected to ~~the~~ action of the ~~total~~ total mass of the rotating portion of support arm 2 and flexure 13 is L_3 , then it is preferable to set the mass M_2 of balancer 93 so as to establish the following formula.

$$L_1 \times M_1 + L_3 \times M_3 = L_2 \times M_2 \quad (5)$$

[0139] Thus, setting ~~the~~ respective centers of gravity of the head slider 1, flexure 13, the rotating portion of support arm 2, and balancer 93 in the head support arm 90, it is possible to prevent the head slider 1 from bumping against the recording medium 12 even in case an impact force is applied thereto. For example, suppose that an impact force is applied in ~~the~~ a direction shown by Q in Fig. 14. Then, impact force F_1 proportional to mass M_1 will act on the head slider 1. Impact force F_2 proportional to mass M_2 will act on the balancer 93. Also, impact force F_3 proportional to total mass M_3 will act on the rotating portion of the support arm and the flexure

13.

[0140] The head support arm 90 is set so as to satisfy the formula (5), and therefore, the relations are established against these impact forces as follows:

$$L_1 \times F_1 + L_3 \times F_3 = L_2 \times F_2 \quad (6)$$

Consequently, even in case of being subjected to external impact forces, the head support arm 90 is free from rotating forces around the rotational axis that connects the respective peaks of the two pivots 11a, 11b of the first base arm 91. Accordingly, it is possible to prevent the head slider 1 from bumping against ~~the~~ a surface of the recording medium 12 ~~causing so as to prevent~~ damage to the magnetic head (not shown) and the recording medium 12 mounted in the head slider 1. That is, the head support arm 90 of the head support device 9 which is free from excessive vibration and reliable against external shocks and the like can be realized by designing it so that ~~the~~ a center of gravity of the head support arm 90 is substantially same as middle point P (not shown) on the line that connects the support arm 2 and the respective peaks of the two pivots 11a, 11b of the first base arm 91. ~~The~~ A head support arm 90 greatest in shock resistance can be realized when ~~the~~ a center of gravity of the head support arm 90 corresponds to ~~the~~ middle point P, and it is also possible to realize ~~the~~ a head support arm 90 having a practically sufficient shock resistance even in case of being ~~off the~~ offset from middle point P provided that ~~it the~~ center of gravity is on the line connecting the respective peaks of the two pivots 11a, 11b of the first base arm 91.

[0141] Also, suppose ~~the~~ a force that acts between the head support arm 90 and the respective peaks of two pivots 11a, 11b of the first base arm 91 is F_4 , and

$$F_1 + F_2 + F_3 > F_4 \quad (7)$$

then, the head support arm 90 is parted from the two pivots 11a, 11b of the first base arm 91.

However, when

$$F_1 + F_2 + F_3 \leq F_4 \quad (8)$$

then, the head support arm 90 is not parted from the two pivots 11a, 11b of the first base arm 91.

Force F_4 that satisfies these conditions is produced by an internal stress generated from ~~the~~ a

rotational moment created by the plate spring 4 ~~that is an elastic member~~ of the support arm 2, but it is possible to freely set the force as described above. Accordingly, it is easy to prevent the head support arm 90 from being parted from the two pivots 11a, 11b of the first base arm 91 even when subjected to impact forces.

[0142] Further, even against ~~the~~ an impact force in ~~the~~ a direction shown by R in Fig. 14, that is, in ~~the~~ a direction parallel to the surface of the recording medium 12, if configured in that the center of gravity of the head support arm 90 corresponds to the rotational axis that connects the respective peaks of two pivots 11a, 11b of the first base arm 91, it is possible to prevent the head slider 1 from bumping against the recording medium 12 because no rotational moment is generated on the head support arm 90.

[0143] Also, in the head support device in the second preferred embodiment, almost the same configuration as that described in the first preferred embodiment can be used as ~~the~~ configuration of the head slider. To avoid repeating ~~the~~ this description, ~~the~~ a detailed description of the head slider is omitted.

[0144] Only ~~the~~ remarkable differences from the head slider of the head support device in the first preferred embodiment will be described here. In the head support device in the second preferred embodiment of the present invention, head 97 is mounted on the head slider 1 ~~is disposed on the head slider 1~~ as shown in Fig. 15, which is positioned ~~most apart~~ remote from the pivot 11a ~~that is the second bearing portion~~.

[0145] Suppose that external impact is applied to the head support device 9. Then, great impact load F is applied to the second bearing portion comprising the plate spring 4 ~~being an elastic member~~ and the pivot 11a for supporting the support arm 2, as shown by the ~~downward~~ downwardly directed arrow in Fig. 15. When an impact force greater than the above impact force is applied, a moment load as shown by arrow B is applied ~~to~~ to the head slider 1 supported by the support arm 2 by ~~means virtue~~ of flexure and dimple 14 as the support arm 2 rotates in the direction shown by arrow A. In the present preferred embodiment, the head 97 is mounted at ~~the~~

a side of the support arm 2 that is apart from the pivot 11a of the support arm 2, and the an air inflow side of the head slider 1 is higher in the an amount of floatation than the an air outflow side where the head 97 is mounted. Accordingly, even when moment B is generated due to the impact load F at the air inflow side being higher in the amount of floatation, the impact is absorbed by the portion being higher in the amount of floatation at the air inflow side, thereby preventing the head slider 1 from bumping against the recording medium 12. Further, since the head 97 is positioned at the a side being free from bumping, the head slider 1 will not bump against the recording medium 12, thereby avoiding to give damage to the head 97.

[0146] Also, when an impact force is applied in the a direction of moving the head slider 1 apart therefrom, as shown by the upward-upwardly directed arrow in Fig. 16, great impact load F' is applied to the second bearing portion comprising the plate spring 4 being an elastic member and the pivot 11a for supporting the support arm 2. The support arm 2 rotates in the direction shown by arrow A', then a rotational moment acts on the head slider 1, causing a rotational force to be applied in the direction of arrow B' to move up the air inflow side of the head slider 1 and making it difficult for the head 97 mounted on the air outflow side hard to come in into contact with the disk medium 12. If the head 97 is in the opposite position, the head slider 1 side is moved up but the air inflow side becomes unstable and the an amount of inflow air is varied causing the floatation of the slider to become unstable.

[0147] Since the head slider in the second preferred embodiment of the present invention has the same configuration as that of the first preferred embodiment, even when an impact force is applied to the head slider, it may prevent the head slider from bumping against the a recording medium or decrease the bumping energy. In addition, in the second preferred embodiment of the present invention, the head is disposed at the an outermost side of the head slider that is most apart from the pivot that becomes the second bearing portion, and thereby, it is possible to realize a disk drive which is excellent in shock resistance.

[0148] Thus, according to the second preferred embodiment, even in case of being subjected

to external shocks, no rotational force is generated around the rotational axis that connects ~~the~~ respective peaks of two pivots of the first base arm. Accordingly, the head slider can be prevented from bumping against ~~the~~ a surface of ~~the~~ a recording medium and causing damage to the magnetic head and the recording medium mounted on the head slider, and it is possible to realize a head support arm of a head support device which is stable and free from excessive vibration.

5 [0149] Also, it becomes possible to increase ~~the~~ rigidity of the ~~whole~~ entire structure, including the support arm, without losing ~~the~~ flexibility thereof while increasing ~~the~~ an activating force to the head slider. Further, since ~~the~~ individual component elements can be separately and independently installed, it is easy to design the head support arm and to expand ~~the~~ freedom of design.

10 [0150] Also, by disposing side reinforcements on either side of the support arm, or forming the plate spring ~~that is an elastic member~~ as another member using a flexible material, and forming the support arm ~~with~~ from a highly rigid material, it is possible to increase ~~the~~ resonance frequency of the support arm, and there will arise no problem of vibration mode that has been a conventional problem. Accordingly, no settling operation is needed, and the support arm can be

15 positioned by rotating it at a high speed and it becomes possible to improve ~~the~~ access speed of the magnetic recording and reproducing unit.

[0151] Further, it is not necessary to carry out forming (bending) of a very accurate elastic member (plate spring) that has been needed in a conventional head support device, and it is possible to manufacture a head support arm and head support device by a simple process.

20 [0152] Also, according to ~~the~~ size of ~~the~~ a recording medium, ~~the~~ length of ~~the~~ an arm portion of either the first base arm or the second base arm can be changed and it is possible to obtain a practical configuration to cope with ~~the~~ standardization in ~~the~~ manufacture of magnetic recording and reproducing units having recording mediums of various sizes and types.

25 [0153] Further, ~~the~~ generation of a vibration mode can be eliminated and ~~the~~ settling time

can be shortened by increasing the resonance frequency of the support arm. Also, the support arm can be position by rotating it at a high speed and it is possible to realize a disk drive having improved in access speed.

[0154] Also, in the head support arm in the second preferred embodiment, a pair of pivots as the bearing portion of the support arm are used ~~for the description~~, but the present invention is not limited to this. It is ~~preferable~~ possible to ~~used~~ use only one pivot. In this case, a configuration in which the support arm rotates only in ~~the~~ a vertical direction can be realized by restricting the movement by the action of both the pivot and the plate spring ~~that is an elastic member~~.

[0155] Also, in the second preferred embodiment, the pair of pivots serving as the rotational axis of the support arm are positioned symmetrical to the longitudinal center line of the support arm, but the present invention is not limited to this configuration.

[0156] In the head support arm of the second preferred embodiment of the present invention, a \sqsubset -shaped through-hole cut away in ~~the~~ a peripheral portion of a tongue-shaped plate spring (elastic member) is shown as an example in Fig. 13 ~~for the purpose of description~~, but the present invention is not limited to this shape, and needless to say, it is also ~~preferable~~ possible to cut away the portion into a U-shaped or V-shaped trapezoidal form.

[0157] In the preferred ~~embodiment~~ embodiments of the present invention, a head support device of a magnetic recording and reproducing unit using a magnetic head is described, but the head support device of the present invention will also bring about similar effects even when it is used as a head support device for a non-contact type disk recording and reproducing unit such as an optical disk drive and optical magnetic disk drive.

[0158] As described above, using the head support device of the present invention, it is possible to provide a head support device having high flexibility and shock resistance and capable of high-speed access while applying a sufficient load to the magnetic head, and in addition, with use of the head support device of the present invention, the support arm can be

vertically moved, whereby it is possible to keep the magnetic head away from ~~the~~ a recording medium when ~~the~~ rotation of the recording medium is stopped.

[0159] Also, since ~~it is configured in that~~ the support arm, having a head slider mounted with a magnetic head at one end thereof, and the first base arm are secured via a plate spring that is an elastic member, and two pivots are disposed on either the support arm or the first base arm, and the support arm is rotated toward ~~the~~ a surface of ~~the~~ a recording medium by the push forces of the respective peaks of the two pivots, thereby pushing the head slider to the surface of the recording medium, there is no generation of rotational force around ~~the~~ a line (rotational axis) that connects the respective peaks of two pivots disposed on either the first base arm or the support arm when subjected to an external impact force. Accordingly, it is possible to prevent the head slider from bumping against the surface of the recording medium and causing damage to the head, mounted ~~with~~ to a head slider, and the recording medium, and to realize a head support arm of a head support device which is stable and free from excessive vibration. And, by using a head support device mounted with such a head support arm, it is possible to realize a disk drive which assures excellent reliability such as high shock resistance and high access speed.

[0160] Further, even when a great impact force is applied while the head slider is ~~being~~ afloat over ~~the~~ a recording medium, the head slider can be prevented from bumping against the recording medium ~~surface,~~ or the bumping energy can be lessened, to prevent the head slider or the recording medium from being damaged. As a result, a highly reliable head support device and disk drive can be manufactured, and it is possible to mount a large-capacity, small-sized and thin disk drive in portable equipment.

ABSTRACT OF THE DISCLOSURE

~~The present invention is a~~ A head support device ~~which~~ is thin and ~~may assure~~ assures
 excellent flexibility and shock resistance while applying a sufficient load to ~~the a~~ head, ~~and a~~ A
 disk drive ~~using~~ uses the head support device. ~~Specifically, it~~ The head support device comprises
 a support arm, ~~and~~ a head disposed at one end of the support arm, which is mounted on a head
 slider so as to be opposed to ~~the a~~ recording medium, an elastic member such as a plate spring
 which ~~renders~~ provides the support arm an activating force in a direction ~~vertical~~ perpendicular
 to the recording medium when the support arm comes to ~~the a~~ rotational center in vertical
 rotation against the recording medium, and a holder connected to the elastic ~~means, wherein~~
~~when~~ member. When an external impact force is applied to the head slider, ~~suppose the~~ with a
 distance from ~~the an~~ action point of load that activates the head slider toward the recording
 medium to ~~the an~~ immovable point in the rotation of the head slider in ~~the a~~ direction of pitch is
 being L_o , and ~~the a~~ length of head slider l in ~~the a~~ direction of air flow is being L_s , then $0.5 < L_o$
 $< L_s < 2$, ~~thereby achieving the purpose. Thus, it is possible to provide a disk drive which may~~
~~assure excellent shock resistance, high access speed, and reliability.~~